Institute of Applied Geosciences
Technical Petrophysics

Slip tendency analysis of 3D faults in Germany

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1. Motivation

Seismicity is a crucial aspect for a repository for nuclear waste. Seismicity is most likely to occur on pre-existing faults. Critical aspects for fault reactivation include:

- Stress field
- Fault geometry

The reactivation potential can be estimated as the slip tendency T_{Seff}, the ratio between maximum resolved shear stress τ and the effective normal stress on the fault plane σ_n':

$$T_{Seff} = \frac{\tau}{\sigma_n'}$$

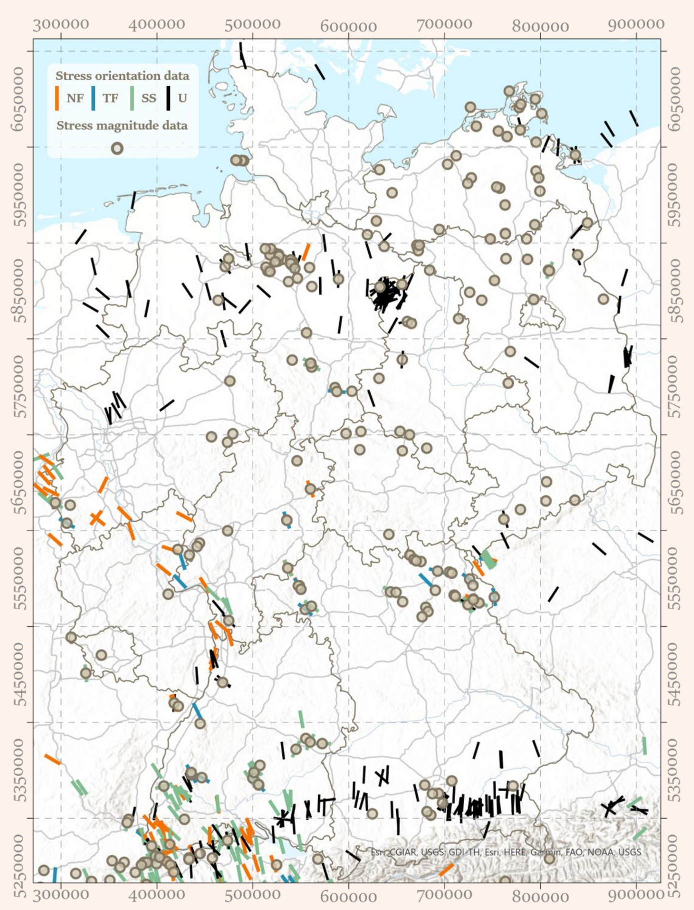

Fig. 1 Stress data in Germany

2. The Stress Field

- The 3D numerical-geomechanical model from the SpannEnD project (Ahlers et al. 2022) provides an estimate of the stress tensor in Germany and adjacent areas.
- This stress tensor can be used for the calculation of T_{Seff}

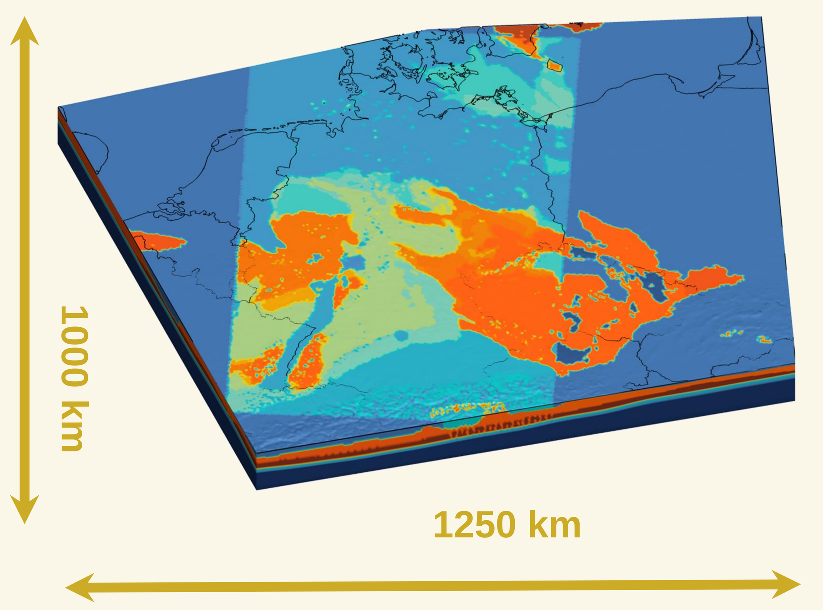

Fig. 2 Numerical-geomechanical model

3. Fault Geometries

3D fault geometries were compiled from geological models from several federal states and further sources (Fig. 3.)

Fig. 3 3D fault geometries

4. Results

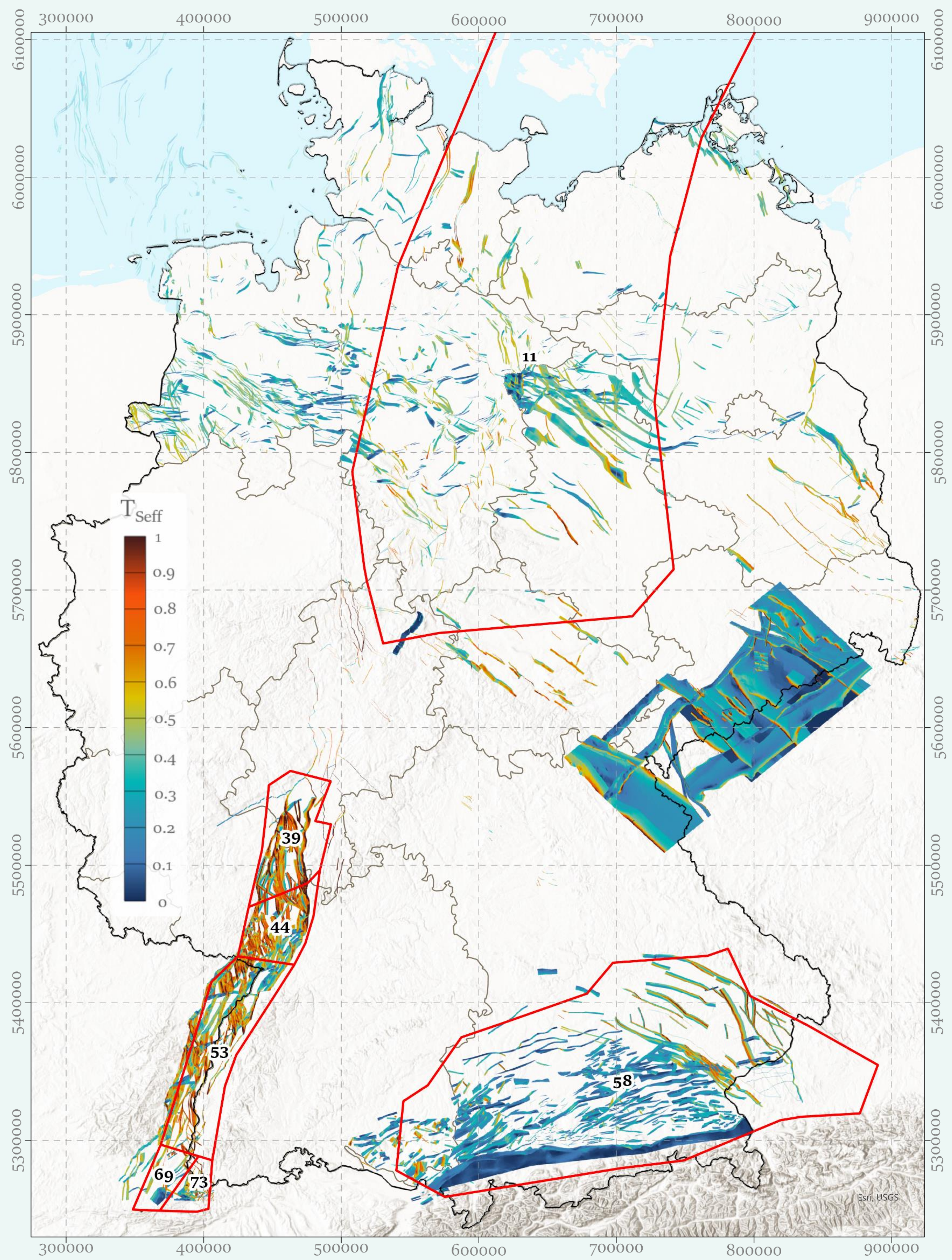

Fig. 4 The results of the T_{Seff} calculation shown in map view. Selected seismic source zones are shown as red polygons with their corresponding ID (Grünthal et al. 2018)

- The stress data from the Germany model are mapped onto the fault geometries. Assuming hydrostatic pore pressure, T_{Seff} has been calculated (Fig. 4.)
- NNE-SSW and NW-SE striking faults show the highest median T_{Seff} values (Fig. 5 a)
- ENE-WSW striking faults show the lowest median T_{Seff} values (Fig. 5 a)
- T_{Seff} strongly decreases with increasing depth (Fig. 5 b)

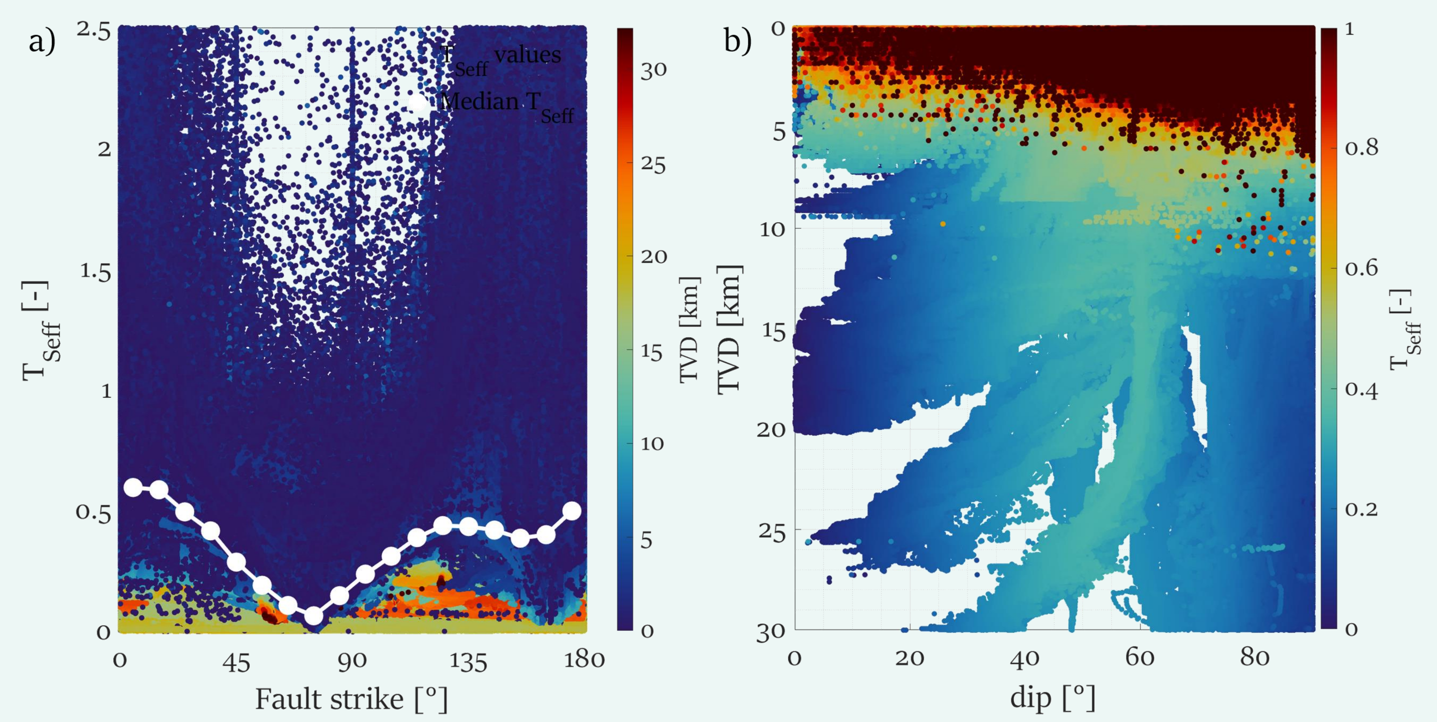

Fig. 5 a) T_{Seff} as a function of fault strike; b) T_{Seff} with depth and fault dip

- T_{Seff} is high in the uppermost 5 km, whereas a majority of seismic events occurs in 8 km depth
- The comparison between the seismicity rates of the seismic source zones and the T_{Seff} of their faults shows a good fit (Fig. 6)

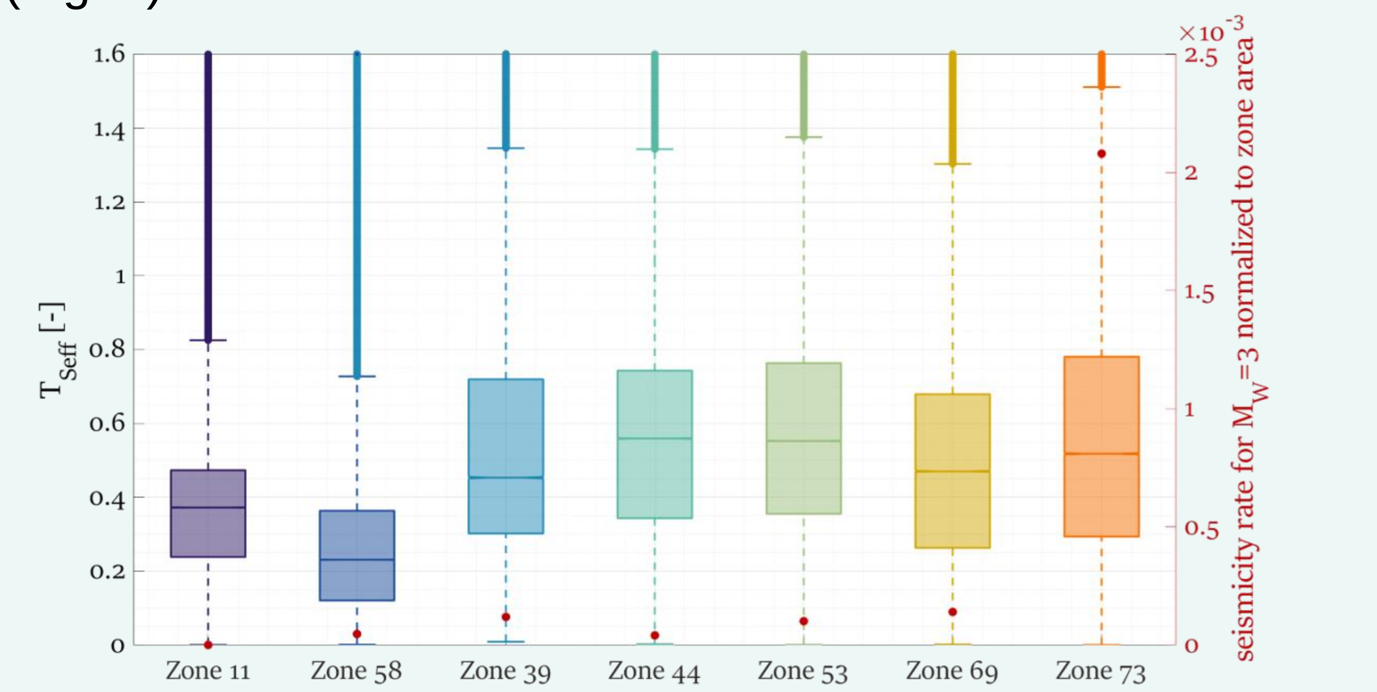

Fig. 6 Boxplots of T_{Seff} of the seismic source zones

Sources
Ahlers, Steffen; Henk, Andreas; Hergert, Tobias; Reiter, Karsten; Müller, Birgit; Röckel, Luisa et al. (2021): 3D crustal stress state of Germany according to a data-calibrated geomechanical model. In: *Solid Earth* 12 (8), S. 1777–1799. DOI: 10.5194/se-12-1777-2021.
Grünthal, Gottfried; Stromeyer, Dietrich; Bosse, Christian (2018): The Source Model of the Probabilistic Seismic Hazard Assessment (PSHA) of Germany - Version 2016. V. 1.0. GFZ Data Services. https://doi.org/10.5880/GFZ.2.6.2018.001
Heidbach, Oliver; Rajabi, Mojtaba; Cui, Xiaofeng; Fuchs, Karl; Müller, Birgit; Reinecker, John et al. (2018): The World Stress Map database release 2016: Crustal stress pattern across scales. In: *Tectonophysics* 744, S. 484–498. DOI: 10.1016/j.tecto.2018.07.007.
Morawietz, Sophia; Heidbach, Oliver; Reiter, Karsten, Moritz; Rajabi, Mojtaba; Zimmermann, Günter et al. (2020): An open-access stress magnitude database for Germany and adjacent regions. In: *Geothermal Energy* 8 (25). DOI: 10.1186/s40517-020-00178-5. ; Ziegler

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